The Oil Drum: Europe
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

EROWI - energy return of water invested

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WATER REQUIREMENTS FOR ENERGY PRODUCTION (Liters per megawatt hour)

Petroleum Extraction	10-40
Oil Refining	80-150
Oil shale surface retort	170-681
NGCC* power plant, closed loop cooling	230-30,300
Coal integrated gasification combined-cycle	~900
Nuclear power plant, closed loop cooling	~950
Geothermal power plant, closed loop tower	1900-4200
Enhanced oil recovery	~7600
NGCC*, open loop cooling	28,400-75,700
Nuclear power plant, open loop cooling	94,600-227,100
Corn ethanol irrigation	2,270,000-8,670,000
Soybean biodiesel irrigation	13,900,000-27,900,000

*Natural Gas Combined Cycle

Energy Return of Water Invested (EROWI). From an article by Robert Service in Science Magazine. The data in the table originate from "Eenergy demands on water resources", report to the congress, 2006

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The readers of "The Oil Drum" are familiar with the concept of "Energy Return of Energy Invested" (EROI or EROEI). It is the ratio of the energy produced by an energy plant during its life cycle to the amount of energy needed to build, operate and dismantle the plant.

EROEI remains one of the most useful parameters that can be used for evaluating an energy technology, but it is not the only one. Another element is the need of water. Water is needed for irrigation of plants to be used as fuel and all large plants using thermal engines need water cooling. We can speak, then, of Energy return of Water Invested (EROWI). It is a concept much more recent than that of EROEI, but which is rapidly gaining attention and may be not less important.

Recently, Robert F. Service reported the comparative table that you can see reproduced at the beginning of this post. The data are taken from an article by Dominguez-faus et al. published in "Environmental Science and Technology" in 2009. Service's paper, as most of the studies published so far in this field, is dedicated to showing how water thirsty biofuels are. It is another drawback for a technology which has also a low EROEI, needs large areas, and competes for land with food production.

But the problem is more general and doesn't just involve biofuels. Nuclear plants, for instance, seem to be especially vulnerable to water scarcity. During the past few years, several plants had to be shut or slowed down, or allowed to drain water into rivers at higher temperatures than considered safe. A set of references on the troubles of nuclear plants during heat waves can be found here .

The problem may affect all thermal plants which are large and inefficient enough; coal plants for instance. According to Service's data, the problem can be eased moving from "once through" to "closed loop" cooling. But, if it were easy, there would be no "once through" plants. Evidently, closed loop cooling is more expensive and, in practice, the result of increasing EROWI may be to reduce EROEI.

Water is, of course, a renewable resource but a lot of the water used today is "fossil" water. It comes from deep aquifers which can be drained empty as it has happened, for instance in Saudi Arabia . In addition, climate change may further reduce the water supply in many areas of the world. How much these factors will affect energy generation worldwide in the near future is difficult to say at present, but surely the problem shouldn't be underestimated. The EROWI problem, in the end, is just an indication that we are hitting yet another limit of our finite environment.

The EROWI concept is examined in depth, especially for biofuels, in an article titled "Burning Water: A Comparative Analysis of the Energy Return on Water Invested" by Kenneth Mulder, Nathan Hagens and Brendan Fisher, in press on AMBIO (The Journal of Human Environment) .